3. The method of claim 1, wherein the reactant stream comprises methane or carbon monoxide and the desired end product comprises hydrogen.

4. The method of claim 1, wherein the reactant stream comprises a titanium compound and the desired end product comprises titanium or titanium dioxide.

5. The method of claim 1, wherein the reaction zone is maintained at a substantially uniform temperature by a hot wall surrounding the reaction zone, with the hot wall surrounded by an insulating layer.

6. The method of claim 5, wherein the insulating layer comprises a material selected from the group consisting of carbon, boron nitride, zirconia, silicon carbide, and combinations thereof.

7. The method of claim 5, wherein the temperature of the reaction zone is maintained between about 1500°C and about 2500°C.

8. A method for thermal conversion of one or more reactants in a thermodynamically stable high temperature gaseous stream to a desired end product in the form of a gas or ultrafine solid particles, the method comprising the steps of:

introducing a stream of plasma arc gas between electrodes of a plasma torch including at least one pair of electrodes positioned adjacent to an inlet end of an axial reactor chamber, the stream of plasma arc gas being introduced at a selected plasma gas flow while the electrodes are subjected to a selected plasma input power level to produce a plasma in a restricted diameter injection line that extends into the reactor chamber and toward an outlet end of the reactor chamber;

thoroughly mixing an incoming reactant stream into the plasma by injecting at least one reactant into the injection line to produce the thorough mixing prior to introduction into the reactor chamber, the reactor chamber maintained at a substantially uniform temperature over the flow field for the reactions to reach

equilibrium;

cooling the gaseous stream exiting a nozzle at the outlet end of the reactor chamber by reducing the velocity of the gaseous stream while removing heat energy at a rate sufficient to prevent increases in its kinetic temperature; and

separating desired end products from gases remaining in the cooled gaseous stream.

9. The method of claim 8, wherein the one or more reactants comprises methane and the desired end product comprises acetylene.

10. The method of claim 8, wherein the one or more reactants comprises methane or carbon monoxide and the desired end product comprises hydrogen.

11. The method of claim 8, wherein the one or more reactants comprises a titanium compound and the desired end product comprises titanium or titanium dioxide.

12. The method of claim 8, wherein the reactor chamber comprises a reaction zone section, which is maintained at a substantially uniform temperature by a hot wall surrounding the reaction zone, with the hot wall surrounded by an insulating layer.

13. The method of claim 12, wherein the insulating layer is surrounded by a cooling layer to prevent degradation of the reaction chamber.

14. The method of claim 12, wherein the insulating layer comprises a carbon layer and the cooling layer comprises a layer of cool water.

15. The method of claim 12, wherein the temperature of the reaction zone of the reactor chamber is maintained between about 1500°C and about 2500°C.

16. The method of claim 12, wherein the temperature of the reaction zone is

maintained between about 1700°C and 2000°.

17. The method of claim 12, wherein the reactants which have passed through the reaction zone are then cooled by directing the product stream thus produced through a coaxial convergent_divergent nozzle positioned in the outlet end of the reactor chamber to rapidly cool the product stream.

18. The method of claim 12, wherein the injection line is maintained at a diameter to produce turbulent flow and thorough mixing of the incoming plasma gases and the reactant stream and wherein the injection line is of a smaller diameter than the diameter of the reaction zone of the reactor chamber.

19. An apparatus for carrying out the method of claim 8.

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31. (Cancelled)

32. (Cancelled)

33. A method for thermally converting one or more reactants in a thermodynamically stable high temperature gaseous stream to a desired end product in the form of a gas or ultrafine solid particles, the method comprising the steps of:

introducing a reactant stream upstream from one end of an axial reactor;

heating the reactant stream as the reactant stream flows axially through an injection line;

passing the reactant stream axially through a reaction zone of the axial reactor, the reaction zone maintained at a substantially uniform temperature over the length of the reaction zone, wherein the axial reactor has a length and a temperature and is operated under conditions sufficient to effect heating of the reactant stream to a selected reaction temperature at which a desired product stream is produced at a location adjacent an outlet end of the axial reactor; and

cooling and slowing the velocity of the desired end product and remaining gaseous stream exiting from the reactor.

34. The method of claim 33, wherein the injection line has a reduced diameter with respect to the axial reactor to produce turbulent flow and thereby thoroughly mix the reactant stream with a heating gas.

35. The method of claim 33, wherein the reactant stream before reaction or thermal decomposition thereof comprises at least one reactant selected from the group consisting of titanium tetrachloride, vanadium tetrachloride, aluminum trichloride and natural gas.

36. The method of claim 33, further comprising the step of separating the desired end product from the remaining gases in the cooled gaseous stream.

37. The method of claim 33, further comprising the step of providing a converging-diverging nozzle arranged coaxially with the outlet end of the reactor to rapidly cool the gaseous stream by converting thermal energy as a result of a adiabatic and isentropic expansion as the gaseous stream flows axially through the nozzle and minimizing back reactions, thereby retaining the desired end product within the flowing gaseous stream.

38. The method of claim 37, wherein the converging-diverging nozzle has a converging section and a diverging section respectively leading to and from a restrictive open throat, the diverging section of the nozzle having a conical configuration.

39. The method of claim 37, wherein the converging-diverging nozzle has a converging section and a diverging section respectively leading to and from a restrictive open throat, the diverging section of the nozzle having a conical configuration with an included angle of less than about 35°.

40. The method of claim 37, wherein the converging-diverging nozzle has a converging section with a high aspect ratio and is configured so that the gaseous stream accelerates rapidly into the nozzle throat while maintaining laminar flow.

41. The method of claim 33, wherein the step of cooling and slowing the velocity of the resulting desired end product and remaining gaseous stream as it exits from the reactor is accomplished by directing a quenching gas into the gaseous stream at a rate that condenses the desired end product and inhibits formation of other equilibrium products as the resulting gaseous stream exits the reactor.

42. The method of claim 37, further comprising the step of controlling the residence time and reaction pressure of the gaseous stream in the reactor by selecting the size of a restrictive open throat within the nozzle.

43. The method of claim 37, further comprising the step of subjecting the gaseous stream to an ultra fast decrease in pressure by smoothly accelerating and expanding the moving gaseous stream along the diverging section of the nozzle to further decrease its kinetic temperature and prevent undesired side or back reactions.

44. The method of claim 33, further comprising a carbon layer surrounding the reaction zone, wherein the carbon layer minimizes radial temperature gradients.

45. The method of claim 33, further comprising a carbon layer surrounding the reaction zone and a cooling layer surrounding the carbon layer, wherein the carbon layer and the cooling layer minimize radial temperature gradients.

46. A method of forming a metal, metal oxide or metal alloy from a metal-containing compound, the method comprising the steps of:

providing a plasma formed from a gas comprising an inert gas, hydrogen, or a mixture thereof;

providing a reagent or a reagent mixture, the reagent or reagent mixture comprising a gaseous or volatilized compound of a selected metal;

thoroughly mixing the reagent or reagent mixture with the plasma upstream from an axial reactor to produce a reactant stream;

passing the reactant stream axially through a reaction zone of the reactor, the reaction zone maintained at a substantially uniform temperature over the length of the reaction zone, wherein the reactor has a length and a temperature and is operated under conditions sufficient to effect heating of the reactant stream to a selected reaction temperature at which a desired product stream is produced at a location adjacent an outlet end of the reactor, thereby forming an equilibrium mixture comprising the selected metal or an oxide or alloy thereof, the selected metal, metal oxide or metal alloy being thermodynamically stable at the reaction temperature;

cooling the gaseous stream exiting the outlet end of the reactor by reducing the velocity of the gaseous stream while removing heat energy at a rate sufficient to prevent increases in its kinetic temperature; and

separating desired end products from gases remaining in the cooled gaseous stream.

47. The method of claim 46, wherein the gaseous or volatilized compound of the selected metal is a gaseous or volatilizable halide.

48. The method of claim 46, wherein the selected metal is titanium, vanadium, or aluminum.

49. The method of claim 46, wherein the compound of the selected metal is titanium tetrachloride, vanadium tetrachloride, or aluminum trichloride.

50. The method of claim 46, wherein the reagent or reagent mixture further comprises at least one additional reagent capable of reacting at the reaction temperature to form an equilibrium mixture comprising an oxide or alloy of the selected metal.

51. The method of claim 46, wherein the method forms titanium metal, and the reagent or reagent mixture comprises titanium tetrachloride.

52. The method of claim 46, wherein the method forms vanadium metal, and the reagent or reagent mixture comprises vanadium tetrachloride.

53. The method of claim 46, wherein the method forms aluminum metal, and the reagent or reagent mixture comprises aluminum trichloride.

54. The method of claim 46, wherein the method forms an alloy of titanium and a second metal, and the reagent or reagent mixture comprises titanium chloride and a gaseous or volatilizable compound of the second metal.

55. The method of claim 54, wherein the second metal is vanadium.

56. The method of claim 46, wherein the method forms a metal oxide of the selected metal, and the reagent or reagent mixture further comprises oxygen.

57. (Currently Amended) The method of claim 46, wherein the method forms titanium dioxide, and the reagent or reagent mixture comprises titanium tetrachloride and oxygen.

58. A method of forming a desired product from a hydrocarbon, the method comprising the steps of:

providing a plasma formed from a gas comprising an inert gas, hydrogen, or a mixture thereof;

providing a reagent or a reagent mixture, the reagent or reagent mixture comprising gaseous or volatilized hydrocarbon;

thoroughly mixing the reagent or reagent mixture with the plasma upstream from an axial reactor to produce a reactant stream;

passing the reactant stream axially through a reaction zone of the reactor, the reaction zone maintained at a substantially uniform temperature over the length of the reaction zone, wherein the reactor has a length and a temperature and is operated under conditions sufficient to effect heating of the reactant stream to a selected reaction temperature at which a desired product stream is produced at a location adjacent an outlet end of the reactor, thereby forming an equilibrium mixture comprising the desired product, the desired product being thermodynamically stable at the reaction temperature; and

cooling the gaseous stream exiting at the outlet end of the reactor by reducing the velocity of the gaseous stream while removing heat energy at a rate sufficient to prevent increases in its kinetic temperature; and

separating desired end products from gases remaining in the cooled gaseous stream.

59. The method of claim 58, wherein the reagent or reagent mixture comprises natural gas.

60. The method of claim 58, wherein the reagent or reagent mixture comprises methane.

61. The method of claim 58, wherein the desired product comprises acetylene.

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